

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE <small>FORM PTO-1390 (REV. 1-98)</small>		ATTORNEY'S DOCKET NUMBER BIF103705/US
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/486065
INTERNATIONAL APPLICATION NO. PCT/FR99/01482	INTERNATIONAL FILING DATE 21 June 1999	PRIORITY DATE CLAIMED 19 June 1998
TITLE OF INVENTION IMPLANT FORMING BIMATERIAL MONOBLOC INTRAOCULAR LENS		
APPLICANT(S) FOR DO/EO/US Marc DOLATKHANI and Alain DEFFIEUX		
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:		
<p>1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.</p> <p>2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.</p> <p>3. <input checked="" type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).</p> <p>4. <input type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.</p> <p>5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)) <ul style="list-style-type: none"> a. <input checked="" type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> has been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). </p> <p>6. <input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)).</p> <p>7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) <ul style="list-style-type: none"> a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been transmitted by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. </p> <p>8. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</p> <p>9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</p> <p>10. <input type="checkbox"/> A translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</p>		
Items 11. to 16. below concern document(s) or information included:		
<p>11. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.</p> <p>12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</p> <p>13. <input checked="" type="checkbox"/> A FIRST preliminary amendment.</p> <p><input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment.</p> <p>14. <input type="checkbox"/> A substitute specification.</p> <p>15. <input type="checkbox"/> A change of power of attorney and/or address letter.</p> <p>16. <input checked="" type="checkbox"/> Other items or information:</p> <p style="margin-left: 20px;">Search Report.</p> <p style="margin-left: 20px;">Inventor information sheet.</p>		

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER		
09/486065	PCT/FR99/01482	BIF103705/US		
17. <input checked="" type="checkbox"/> The following fees are submitted:		CALCULATIONS PTO USE ONLY		
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):				
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO		\$ 970.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO		\$840.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO		\$760.00		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)		\$670.00		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)		\$96.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =				
Surcharge of \$130.00 for furnishing the oath or declaration later than <input checked="" type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		\$ 130		
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$
Total claims	18 - 20 =	0	x \$18.00	\$ 0
Independent claims	1 - 3 =	0	x \$78.00	\$ 0
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$260.00	\$
TOTAL OF ABOVE CALCULATIONS =		\$ 970		
Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).		+		
SUBTOTAL =		\$ 970		
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).		\$		
TOTAL NATIONAL FEE =		\$ 970		
Fee for recording the enclosed assignment (37 CFR 1.21(h)): The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +		\$		
TOTAL FEES ENCLOSED =		\$ 970		
		Amount to be refunded:		\$
		charged:		\$
<p>a. <input checked="" type="checkbox"/> A check in the amount of \$ <u>970</u> to cover the above fees is enclosed.</p> <p>b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.</p> <p>c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required by 37 CFR 1.16 and 1.17, or credit any overpayment to Deposit Account No. 25-0120. A duplicate copy of this sheet is enclosed.</p>				
<p>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.</p> <p>Customer No. 000466</p> <p>SEND ALL CORRESPONDENCE TO:</p> <p>Young & Thompson 745 South 23rd Street 2nd Floor Arlington, VA 22202 (703) 521-2297</p> <p>February 22, 2000</p> <p><i>Benoit Castel</i> SIGNATURE</p> <p>Benoit Castel NAME</p> <p>35,041 REGISTRATION NUMBER</p>				

**VERIFIED STATEMENT CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) & 1.27(c))--SMALL BUSINESS CONCERN**

Docket Number (Optional)

Applicant or Patentee: Marc DOLATKHANI and Alain DEFFIEUXSerial or Patent No.: PCT/FR99/01482Filed or Issued: JUNE 21, 1999Title: Implant forming bimaterial monobloc intraocular lens.

I hereby declare that I am

- the owner of the small business concern identified below:
 an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF SMALL BUSINESS CONCERN IOLTECHNOLOGIE-PRODUCTIONADDRESS OF SMALL BUSINESS CONCERN Rue de la Désirée, La ville en Bois,
17000 LA ROCHELLE, FRANCE

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.12, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention described in:

- the specification filed herewith with title as listed above.
 the application identified above.
 the patent identified above.

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights in the invention must file separate verified statements averring to their status as small entities, and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(e) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

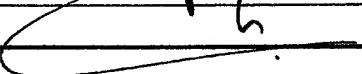
Each person, concern or organization having any rights in the invention is listed below:

- no such person, concern, or organization exists.
 each such person, concern or organization is listed below.

Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Philippe TOURRETTETITLE OF PERSON IF OTHER THAN OWNER P.D.G. (General Manager)ADDRESS OF PERSON SIGNING Pommerac, 17220 Clavette FRANCESIGNATURE  DATE 24/02/2000

09/486065
514 Rec'd PCT/PTO 22 FEB 2000

PATENTS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of
Marc DOLATKHANI et al.
Serial No. (unknown)
Filed herewith

IMPLANT FORMING BIMATERIAL
MONOBLOC INTRAOCULAR LENS

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents

Washington, D.C. 20231

Sir:

Prior to calculation of the filing fee, please amend the above-identified application as follows:

IN THE CLAIMS:

Claim 3, line 1, change "either claim 1 or claim 2" to --claim 1--.

Claim 4, line 1, change "any one of claims 1 to 3" to --claim 1--.

Claim 8, line 1, change "any one of claim 1 to 7" to --claim 1--.

Claim 9, line 1, change "any one of claim 1 to 8" to --claim 1--.

Claim 10, line 1, change "any one of claim 1 to 8" to --claim 1--.

Claim 11, lines 1 and 2, change "any one of claim 1 to 10" to --claim 1--.

Claim 12, line 2, change "any one of claims 1 to 11" to --claim 1--.

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Claim 14, line 1, cancel "or 13".

Claim 15, lines 1 and 2, change "any one of claims
12 to 14" to --claim 12--.

Claim 18, lines 1 and 2, change "any one of claims
12 to 14" to --claim 12--.

Respectfully submitted,

YOUNG & THOMPSON

By

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February 22, 2000

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IMPLANT FORMING BIMATERIAL MONOBLOC INTRAOCULAR LENS

The invention relates to an implant forming an intraocular lens and intended for implantation in the eye of a patient who is lensed or lensless (aphacic) following extraction of the opacified natural crystalline lens, or for correction of refractive ametropias.

In the case of an eye which is aphacic following opacification of the natural crystalline lens (cataract) the implant is generally placed in the posterior chamber in the capsular sac situated behind the iris, but can also be implanted in the ciliary sulcus or in the anterior chamber in front of the iris.

In the case of a lensed eye, implantation with the aim of correcting a refractive ametropia generally takes place in front of the iris, since the capsular sac is still occupied by the natural crystalline lens. However, it is also possible to envisage implantation behind the iris, between the iris and the crystalloid substance.

All implants which form an intraocular lens include a central optical part, whose overall contour is circular, and a haptic part, which is disposed at the periphery of the optical part and is intended to be positioned so as to stabilize the implant.

Numerous types of implants referred to as rigid implants are known, commonly being made of polymethyl methacrylate (PMMA). Such implants require a major sclerocorneal incision and risk damaging the ocular tissues.

In order to overcome this problem, attempts have been made to develop implants referred to as flexible implants, made in particular of hydrogel, hydroxyethyl methacrylate (HEMA) and flexible acrylic material. These implants can be folded or rolled up on themselves, in particular about a diametral axis of the optical part, for

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introduction via a small incision, allowing rapid sclerocorneal cicatrization.

One known flexible implant comprises a central, lens-forming optical element and two haptic elements at the periphery of the optical element. With flexible implants of this type, made in particular of hydrogel, hydroxyethyl methacrylate (HEMA) and flexible acrylic material, the problems of positioning and stabilization are more difficult to solve than with other, rigid implants.

In the case of implantation following extraction of the opacified crystalline lens, it is known that the implants are difficult to maintain in a stable position owing to the fact that the cut made in the anterior capsule is not, in practice, perfectly centered. The cut edge of said anterior capsule therefore covers the haptic branches to differing extents. Consequently, in the weeks following the operation, the axial component of the force which is exerted by contraction of the cut edge of the anterior capsule on a haptic element can vary depending on the position of the implant in the capsular sac. One of the haptic branches can be drawn backward, such that correct positioning of the implant in the capsular sac is not ensured.

Likewise, in the case of implantation in a lensed eye, the position of the implant must be stable in order to prevent any displacement or contact of certain parts of the implant with the internal eye tissues.

In an attempt to resolve these difficulties, the production has been considered of bimaterial intraocular implants, i.e., implants comprising an optical part in a first material, generally flexible, allowing folding and rolling, and haptic parts made of a second, rigid material, such as PMMA, in order to ensure a good hold and stability of the lens following implantation.

EP208546 describes an implant comprising an optical

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part made of PMMA and a haptic part, made of polypropylene, at the periphery of the optical part. Subsequently, mechanical integration is ensured by virtue of a laser beam which softens the material, which subsequently hardens after cooling. An operation of this kind is complicated and considerably increases the production costs of the lens.

Also known is an intraocular lens comprising an optical part made of flexible material and a haptic part made of rigid material, such as PMMA, which ensures bonding by fusion of the two materials in the contact zone. The process of manufacture of such a lens likewise exhibits disadvantages. Specifically, the positioning of the haptic parts relative to the periphery of the optical part is not easy, so leading to an increase in the manufacturing costs of the lens. Defects may also become evident at the junction zone, bringing with them a risk of separation of the haptic part.

One object of the invention is to provide an implant which forms an intraocular lens and which suffers neither from the disadvantages of monobloc intraocular lenses made from rigid material or flexible material nor from the disadvantages of bimaterial implants which involve the fusion or assembly of the haptic and optical parts.

The implant for a lensed or aphacic eye, according to the invention, comprises:

an optical part and a haptic part, the optical part being made at least partially of flexible material and the haptic part being made at least partially of rigid material, wherein the structure of said implant is monobloc.

According to one provision of the invention, the rigid material is the flexible material in a form modified by at least one reaction selected from chemical reactions and polymerization reactions.

The optical part can be made entirely of flexible

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material or can comprise one or more strips made of flexible material alternating with strips made of rigid material. Whatever the embodiment, the rigid material of the optical part allows said part to be folded or rolled in order that it can be introduced through a small incision.

In accordance with one variant embodiment, the optical part comprises a zone made of rigid material which adjoins the haptic part and is in continuity with the rigid material of the optical part.

10 In practice, the haptic part will be made entirely of rigid material. It may comprise one (or more) zone(s) made of flexible material.

15 The flexible material of the implant which forms an intraocular lens is generally hydrophilic, but may also be selected from polysiloxanes, which are not (generally) hydrophilic; their flexibility is due to a very low glass transition temperature (T_g).

20 The flexible material of the implant which forms an intraocular lens is advantageously selected from crosslinked polymer and copolymer materials such as, for example, random methyl methacrylate-hydroxymethyl methacrylate (MMA-HMA) copolymers crosslinked by the addition of a polyfunctional agent such as diethylene glycol dimethacrylate. The flexible material of the lens is based, for example, on PMMA-PHMA copolymers, crosslinked with diethylene glycol dimethacrylate.

25 The implant of the present invention is notable in that it is both monobloc and bimaterial. The rigid material results from a structural modification of the flexible material. The implant of the invention thus consists of two materials, a flexible material and a rigid material, without any fusion or assembly of these two materials.

30 The combination of the two features, monobloc and bimaterial, in the implant according to the invention gives 35 it a reliability and a longevity which are superior to

those of known bimaterial lenses made by fusion or assembly.

The process of manufacturing the implant comprises a first step of producing a preform (or blank) which can be shaped into an intraocular lens from a flexible monobloc starting material, a step of shaping of said preform into an intraocular lens, characterized in that said process further comprises a step of structurally modifying at least one zone of the preform which it is intended should become rigid.

In accordance with one provision of the invention, the step of structural modification comprises a phase of impregnating the zone of the preform with reactive organic compounds.

The step of structurally modifying the starting material can be carried out by deploying a chemical reaction and/or a polymerization reaction.

In a first embodiment of the invention, the shaping step, which is commonly carried out by machining, precedes the step of structurally modifying the starting material. In such a case, it is appropriate to carry out a step of protecting at least one zone of the preform which it is intended should remain flexible, prior to the step of structurally modifying the starting material, and then to remove protection from this zone of the preform which it is intended should remain flexible.

In accordance with another embodiment of the invention, the shaping step (machining) follows the structural modification step.

The process of the invention therefore breaks down into four distinct steps:

- premachining step (production of a preform or blank)
- selective impregnation step
- step of modification by chemical reaction and/or

polymerization

- step of removing protection or machining (shaping of the preform).

5 A number of approaches can be used, individually or in combination:

- chemical reaction between a monofunctional or polyfunctional compound and a reactive element of the material of the lens.

10 - polymerization of one or more monomers within the material of the lens.

- polymerization of a mixture of monomers and polymers outside the material of the lens.

In accordance with a first embodiment of the invention, the anchoring of groups on the material of the lens and/or the formation of an interpenetrated polymer network makes it possible to modify, durably and irreversibly, the characteristics of the modified zone which it is intended should constitute the rigid part, and, in particular, to increase its rigidity (increase in modulus, reduction in hydrophilicity, etc.).

20 In accordance with another embodiment of the invention, the anchoring of functional groups on the material of the lens allows copolymerization with a mixture of monomers and/or polymers (formation of MOPO).

25 In the case of MMA-HMA copolymers, for example, it is possible to utilize the reactivity of the hydroxyls of HMA units in order to attach groups capable of modifying the characteristics of the material.

30 In this case, the possible reactions can be grouped into five categories:

35 - the reactive compound used is monofunctional. Its reaction with the reactive functions of the material of the lens results in chemical modification of the structure of the material and in a decrease in its hydrophilicity. By way of example, mention may be made of functional monomers

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such as functional styrene derivatives (chloromethylstyrene, carboxystyrene), acrylic and methacrylic acids and their derivatives (acryloyl and methacryloyl halides, acryloyl and methacryloyl anhydrides), allyl halides, etc. (carboxylic compounds and their derivatives (especially acid halides), isocyanates, alkyl halides, epoxides, etc.)

- the reactive compound is polyfunctional. The various functions are antagonistic to the functions of the material of the lens and are capable of reacting with them. This compound then serves as a coupling agent between the different polymer chains of the material. This method permits a reduction in the hydrophilicity of the material and an increase in the crosslinking density, which raises the rigidity of the material. By way of example, mention may be made of divinyl sulfone and its derivatives, (polyfunctional) carboxylic compounds and their derivatives, polyfunctional alkyl halides, di- and tri-isocyanates, polyfunctional epoxides, etc.

- the reactive compound used is polyfunctional. One or more of its functions are antagonistic to the functions of the material and are capable of reacting with them. The remaining function or functions is or are polymerizable and allows or allow postpolymerization so as to increase the crosslinking density and raise the rigidity of the material of the lens. By way of example, mention may be made of functional monomers such as functional styrene derivatives (chloromethylstyrene, carboxystyrene, etc.), acryloyl and methacryloyl halides, allyl halides, etc.

- the compounds are monomers which impregnate the material and penetrate the network formed by said material. A polymerization reaction then forms interpenetrated networks, thereby increasing the rigidity of the material. By way of example, mention may be made of compounds such as mono- or polyfunctional acrylic and alkylacrylic monomers,

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heterocyclic monomers such as propylene oxide, etc.

- the reactive compound used is polyfunctional. One or more of its functions are antagonistic to the functions of the material and are capable of reacting with them. The remaining function or functions is or are copolymerizable with a mixture of monomers and/or a polymer blend. By way of example, the reactive compound can be methacrylic acid, acrylic acid or an alkylacryloyl halide (methacryloyl chloride in particular), it being possible for the mixture of monomers to be a mixture of styrene, acrylic and alkylacrylic derivatives and it being possible for the polymers to be PMMA, poly(methyl methacrylate-co-styrene), poly(methyl methacrylate-co-alkyl acrylate) and poly(methyl methacrylate-co-alkylacrylate) and poly(methyl methacrylate-co-alkyl alkylacrylate). The monomer mixture/polymer blend is combined with a free-radical initiator.

So as to penetrate the interior of the material, in order to modify it right through, the reactive compounds must, preferably, be miscible with the copolymer chains and must, consequently, possess an appropriate chemical structure.

On premachined lenses it is also possible to carry out surface modification of the zone or zones to be rigidified. Under these conditions, however, the properties obtained are less satisfactory.

The partial and selective impregnation of a specific zone of the lens (which it is intended should become the rigid part) requires the part which it is intended should remain flexible not to be in contact with the reactive compounds. This can be realized in a number of ways:

- in the case of ready-machined lenses, by protecting the part of the lens which it is intended should remain flexible by a temporary impermeable coating, which

is subsequently removed;

- in the case of preformed blanks, by an appropriate cutout, which ought to allow rapid impregnation by diffusion of the organic reactive compounds into the zone to be rigidified, which it is intended should become the rigid part, in particular by cutting or premachining thereof. The part which ought to remain flexible, which is not machined, is protected by an overthickness of material, said material preventing the diffusion of the organic reactive compounds to the core of the material which will constitute the flexible part of the lens.

The part which has remained flexible is, finally, exposed by machining following the steps of impregnation and chemical reaction.

In accordance with a first embodiment of the invention, the impregnating step is carried out with an impregnating solution composed, for example, of methacryloyl halide, (in particular, methacryloyl chloride) and a free-radical initiator such as benzoyl peroxide, or of a mixture of methyl methacrylate, acrylic acid, methacryloyl chloride, ethylene glycol dimethacrylate and a free-radical initiator such as azo(bis)isobutyronitrile.

The impregnating step is commonly carried out at ambient temperature, at approximately 20°C, for a period of from 1 h to 48 h, depending on the thickness of the zone to be rigidified, and on the desired rigidity. Increasing the temperature makes it possible to reduce the impregnation time.

In accordance with another embodiment of the invention, the impregnating solution is composed exclusively of a polyfunctional compound such as methacrylic acid or an alkyacryloyl halide (especially methacryloyl chloride).

The modification step is carried out by adding a mixture of monomers and/or a polymer blend in combination

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with a free-radical initiator. The copolymerization temperature is between 20 and 95°C for a period of from 1 h to 48 h.

The step of structural modification by chemical reaction and/or polymerization reaction is carried out under an inert atmosphere at a temperature of between 30°C and 95°C. A pressure of approximately 1 to 5.10^5 Pa makes it possible to limit the evaporation of the reactants.

The duration of this step is between a few minutes and 48 h, depending on the temperature and on the nature of the catalyst or initiator which is used. The hardness or rigidity which is required for the rigid part is a function of the rate of the chemical modification and/or polymerization reaction.

Regarding the chemical reactions which lead to structural modification of the material, Lewis acids and bases can be used as catalysts. By way of example, mention may be made of the catalysts BF₃, TiCl₄, amines, etc.

Free-radical polymerization initiators are usually employed for polymerization reactions. By way of example, mention may be made of peroxides, hydroperoxides, percarbonates, redox couples, azonitriles, etc. The initiators used must possess, preferably, a chemical structure which is adapted so as to diffuse into the chains of the material and must have a half-life which is compatible with the chosen polymerization temperature and polymerization time.

The step of removing protection from the protected part of the lens, in the case of premachined lenses, or the machining of the blank, makes it possible to create a nonmodified flexible part and a rigidified zone.

The process of the invention for structural modification by selective rigidification, described above, makes it possible to obtain implants featuring haptic parts having attachment members of various geometric shapes,

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attachment members having damping elements, or flat haptic parts or other haptic parts of any desired configuration.

The lenses are subsequently placed in an aqueous medium in order to induce the swelling of the flexible part and to remove the unreacted products by washing.

The process of the invention will also be described by means of the following nonlimiting examples.

The starting lenses are flexible lenses based on PMMA-PHMA copolymers whose characteristics are as follows:

- HMA content: approximately 60 molar %
- MMA content: approximately 40 molar %
- ethylene glycol dimethacrylate: approximately 0.25 molar %
- in aqueous medium, the degree of swelling is 28%.

Example 1

The impregnating solution is composed of 3 ml of methacryloyl chloride. Impregnation is carried out by soaking the preform at 20°C for from 4 to 24 h depending on the thickness of the part to be rigidified and the rigidity desired.

Example 2

The impregnating solution is composed of 3 ml of methacryloyl chloride and 300 mg of benzoyl peroxide. Impregnation is carried out by soaking the preform at 20°C for from 4 to 24 h depending on the thickness of the part to be rigidified and the rigidity desired.

Example 3

The impregnating solution is composed of 1.5 ml of methyl methacrylate, 1.5 ml of methacryloyl chloride and 300 mg of benzoyl peroxide. Impregnation is carried out by soaking the preform at 20°C for from 4 to 24 h depending on the thickness of the part to be rigidified and the rigidity desired.

Example 4

The impregnating solution is composed of 2.7 ml of

methacryloyl chloride, 0.3 ml of ethylene glycol dimethacrylate and 300 mg of benzoyl peroxide. Impregnation is carried out by soaking the preform at 20°C for from 4 to 24 h depending on the thickness of the part to be rigidified and the rigidity desired.

Example 5

The impregnating solution is composed of 2.4 ml of acrylic acid, 0.6 ml of methacryloyl chloride and 300 mg of benzoyl peroxide. Impregnation is carried out by soaking the preform at 20°C for from 4 to 24 h depending on the thickness of the part to be rigidified and the rigidity desired.

Example 6

The impregnating solution is composed of 2 ml of methyl methacrylate, 0.7 ml of acrylic acid, 0.3 ml of ethylene glycol dimethacrylate and 300 mg of azo(bis)isobutyronitrile. Impregnation is carried out by soaking the preform at 20°C for from 4 to 24 h depending on the thickness of the part to be rigidified and the rigidity desired.

The step of structural modification by chemical reaction and/or polymerization is carried out under an inert atmosphere at a pressure of approximately 2.10^5 Pa. The duration of this step is between 4 and 24 hours depending on the desired rigidity or hardness and in accordance with the amount of polymerization- or reaction-initiating agent which is present in the medium, and in accordance with the desired rigidity for the rigid part.

The step of protecting the flexible part of the lens, in the case of premachined lenses, or the machining of the blank, makes it possible to create a nonmodified part, which has remained flexible, and a zone which has become rigid.

In one embodiment, only the haptic parts or the portions in which the haptic parts are to be formed are

impregnated. In a variant embodiment, zones of the optical part adjoining the haptic parts may also be impregnated. Similarly, one or more strips, parallel to a diameter, for example, can be impregnated, strips alternating with the aforementioned strips being protected so as to remain flexible. It will be understood that such strips allow the optical part to be folded or rolled around the zones which have remained flexible.

Example 7

The impregnating solution is composed of 1.5 ml of methacryloyl chloride. The duration of impregnation is 4.5 h. The step of copolymerization is carried out by adding a mixture of PMMA and methyl methacrylate, n-butyl methacrylate and benzoyl peroxide.

Example 8

The impregnating solution is composed of 1.5 ml of methacryloyl chloride. The duration of impregnation is 4.5 h. The step of copolymerization is carried out by adding a mixture of PMMA and methyl methacrylate, n-butyl methacrylate, hydroxyethyl methacrylate and benzoyl peroxide.

Example 9

The impregnating solution is composed of 1.5 ml of methacryloyl chloride. The duration of impregnation is 4.5 h. The step of copolymerization is carried out by adding a mixture of PMMA and methyl methacrylate, n-butyl methacrylate, hydroxyethyl methacrylate, ethylene glycol dimethylacrylate and benzoyl peroxide.

Example 10

The impregnating solution is composed of 1.5 ml of methacryloyl chloride. The duration of impregnation is 4.5 h. The step of copolymerization is carried out by adding a mixture of poly(methyl methacrylate-co-styrene), methyl methacrylate, n-butyl methacrylate, ethylene glycol dimethylacrylate and benzoyl peroxide.

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Example 11

The impregnating solution is composed of 1.5 ml of methacryloyl chloride. The duration of impregnation is 4.5 h. The step of copolymerization is carried out by adding a mixture of poly(methyl methacrylate-co-ethyl acrylate), methyl methacrylate, n-butyl methacrylate, ethylene glycol dimethylacrylate and azo(bis)isobutyronitrile.

Example 12

The impregnating solution is composed of 1.5 ml of methacryloyl chloride. The duration of impregnation is 4.5 h. The step of copolymerization is carried out by adding a mixture of poly(methyl methacrylate-co-ethyl methacrylate), methyl methacrylate, n-butyl methacrylate, ethylene glycol dimethylacrylate and benzoyl peroxide.

These examples do not limit the possibilities provided by the present invention. Similarly, the impregnating step can be conducted such that the zones to be treated have a variable hardness as a function, in particular, of the geometry and of the duration of impregnation.

The person skilled in the art will understand that, although the invention has been described and illustrated for specific embodiments, it is possible to envisage numerous variant embodiments while remaining within the scope of the invention as defined in the attached claims.

CLAIMS

1. Implant forming an intraocular lens for a lensed or aphacic eye, comprising an optical part and a haptic part, the optical part being made at least partially of flexible material and the haptic part being made at least partially of rigid material, characterized in that the structure of said implant is monobloc.

5 2. Implant according to claim 1, characterized in that the rigid material of the implant has a shape modified by at least one route selected from chemical reactions and polymerization reactions of the flexible material constituting the other parts of the implant.

10 3. Implant according to either claim 1 or claim 2, characterized in that the flexible material constituting one part of the implant is hydrophilic.

15 4. Implant according to any one of claims 1 to 3, characterized in that the flexible material constituting the implant is selected from crosslinked polymer and copolymer materials.

20 5. Implant according to claim 4, characterized in that the copolymer materials are based on random methyl methacrylate-hydroxymethyl methacrylate (MMA-HMA) copolymers crosslinked by the addition of a polyfunctional agent.

25 6. Implant according to claim 5, characterized in that the polyfunctional agent is diethylene glycol dimethacrylate.

7. Implant according to claim 4, characterized in that the polymer materials are selected from polydimethylsiloxanes.

30 8. Implant according to any one of claims 1 to 7, characterized in that the optical part comprises one or more strips made of flexible material alternating with strips made of rigid material.

35 9. Implant according to any one of claims 1 to 8, characterized in that the optical part comprises a zone

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made of rigid material which adjoins the haptic part and is in continuity with the rigid material of the haptic part.

10. Implant according to any one of claims 1 to 8, characterized in that the optical part is primarily made of flexible material and the haptic part is primarily made of rigid material.

11. Implant according to any one of claims 1 to 10, characterized in that the haptic part consists of attachment members.

10 12. Process for manufacturing an implant according
to any one of claims 1 to 11, comprising a first step of
producing a preform (or blank) which can be shaped into an
intraocular lens from a flexible monobloc starting
material, a step of shaping said preform into an
15 intraocular lens, characterized in that said process
further comprises a step of structurally modifying at least
one zone of the preform which it is intended should become
rigid.

13. Process according to claim 12, characterized
in that the step of structural modification comprises a
phase of impregnating the zone (or zones) of the preform
which it is intended should become rigid.

14. Process according to claim 12 or 13,
characterized in that the step of structurally modifying
the starting material comprises at least one reaction of
the organic compounds with the starting material, selected
from chemical reactions and polymerization reactions.

15. Process according to any one of claims 12 to
14, characterized in that the machining step precedes the
step of structurally modifying the starting material.

16. Process according to claim 15, characterized in that it comprises a step of protecting the zone of the preform which it is intended should remain flexible.

17. Process according to claim 16, characterized
35 in that it comprises a step of removing protection from the

zone of the preform which it is intended should remain flexible.

18. Process according to any one of claims 12 to 14, characterized in that the machining step follows the structural modification step.

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